ON THE EFFECT OF A MAGNETIC FIELD ON THE SERVOMECHANISMS

MISS H. SINHA

69A, EKDALIA ROAD, BALLYGUNGE, CALCUTTA-19, INDIA

(*Received December* 26, 1967; *Resubmitted July* 5, 1968)

It is well-known that magnetic fields play an important role in the electronic devices, servomechanisms, in the theory of automatic contiol, vide Lewis (1962). It is, therefore, worthwhile to consider the effect of a magnetic field in a simple problem of servo-mechanism, that forces the angle of turn of a rotating shaft to follow the angle of turn of a pointer or indicator. The source of power, motors and generators and other electrical equipment may be contained in the servomechanism. As is customary, the damping in the system is provided by a component of torque proportional to the rate of deviation. The object of this note is to accommodate a magnetic field in the above system.

We consider servomechanisms that force the angle of turn $\theta_0(t)$ of rotating shaft to follow closely the angle of turn $\theta_i(t)$ of a pointer where t denotes the time.

If $\phi(t)$ be the angle of deviation between shaft and pointer then

$$\phi(t) = \theta_0(t)-\theta_i(t) \tag{1}$$

Since the product of moment of inertia I and angular acceleration $\theta_0''(t)$ of the shaft is equal to the torque applied to the shaft, we have

$$I\theta_0''(t) = -K\phi(t)-C\phi'(t) - \mu KH_0^2\theta_0'(t) \tag{2}$$

wheie K, C are positive constants, μ is the magnetic permeability, H_0 the intensity of the magnetic field, $\phi'(t)$ the rate of deviation and $\theta_0'(t)$ the rate of angle of turn $\theta_0(t)$ of the rotating shaft. The initial conditions are

$$\theta_0(0) = \theta_0'(0) = 0$$

and also from (1) we have

$$\phi(0) = -\theta_i(0)$$

Introducing Laplace transform of parameter $s(>0)$ in (2) and simplifying, we find

$$(Is^2+\mu KH_0^2)\theta_0(s) = -(K+Cs)\phi(s)-C\theta_i(0) \quad .. \quad (3)$$

In equation (2) $\theta_0(t)$, $\theta_0'(t)$, and $\phi(t)$ and hence $\theta_i(t)$for continuous when $t > 0$

Siince $\qquad \theta_0(s) = \phi(s)+\theta_i(s)$

(3) gives

$$\phi(s) = \frac{-Is^2\theta_i(s)+C\theta_i(0)}{Is^2+(C+\mu KH_0^2)s+K} \quad .. \quad (4)$$

Let us use the input angle $\theta_i(t) = A$ (a constant), then

$$\theta_i(0) = A \text{ so that } \theta_i(s) = \frac{A}{s}$$

It, then follows that (5) changes to the form

$$\phi(s) = -A\left[\frac{s+b}{(s+b)^2+\omega^2} + \frac{CA/I}{(s+b)^2+\omega^2}\right]$$

where $$b = \frac{C+\mu KH_0^2}{2I}, \quad \omega^2 = \frac{K}{I} - \frac{(C+\mu KH_0)^2}{4I^2}$$

Expressing in terms of inverse transform, we have

$$\phi(t) = -Ae^{-bt}\cos\omega t + \frac{Ab}{\omega}e^{-bt}\sin\omega t - \frac{CA}{I\omega}e^{-bt}\sin\omega t \quad .. \quad (5)$$

Let us now assume that $K > \frac{(C+\mu KH_0^2)^2}{4I}$; then the necessary condition for the relation to held is that H_0 must be such that $H_0^2 < I/C\mu$

For, $$\omega^2 = \frac{K}{I} - \frac{(C+\mu KH_0^2)^2}{4I^2}$$

$$= \frac{4KI-(C+\mu KH_0^2)^2}{4I^2}$$

or $$4I^2\omega^2 = -\mu^2H_0^2K^2(2I-C\mu H_0^2)K-C^2$$

A necessary condition for $\omega^2 > 0$ is that

$$(2I-C\mu H_0^2)^2-C^2\mu^2H_0^4 \equiv 4I(I-C\mu H_0^2) > 0$$

so that $$H_0^2 < \frac{I}{C\mu} \quad \text{or} \quad H_0 < \sqrt{\frac{I}{C\mu}} \, .$$

It, therefore, follows that the angle of deviation $\phi(t)$ suffers a damping in the absence of the magnetic field. But a magnetic field influences the damping i.e. the damping is increase to the extent of addition of a term in the decay coefficient.

The damped oscillation has the initial value A. For small oscilations, we can write

$$\phi(t) = -Ae^{-bt} + Abte^{-bt} - \frac{CA}{I}te^{-bt} \quad .. \quad (6)$$

which is evidently transient in character.

REFERENCE

Lewis, J. A., 1962. *Quart. Appl. Maths.*, **20**, 13.

17

LOW TEMPERATURE MAGNETIC INVESTIGATION IN SINGLE CRYSTALS OF SOME PSEUDO-TETRAHEDRAL Cu(II) AND Ni(II) CHELATES

S. LAHIRY, D. MUKHOPADHYAY AND D. GHOSH
(Nee GUHA THAKURTA)

MAGNETISM DEPARTMENT, INDIAN ASSOCIATION FOR THE CULTIVATION OF SCIENCE CALCUTTA-32, INDIA

(*Received August* 9, 1968)

Following our magnetic studies (Lahiry *et al*, 1966, Bose *et al* 1965) on several tetrahedral copper (II) compounds of the general formula M^I_2 [CuX_4] where M^I = Cs, and $(CH_3)_4N$, X = Cl, and Br, we now report the preliminary low temtepratnre magnetic investigation of the following chelate complexes :

(i) copper (II) bis (–N-isopropylsalicylaldiminato), (ii) copper (II)-bis (N-*t*-butylsalicylaldiminato) and (iii) nickel (II) bis (N-isopropyl-salicylaldiminato. All these crystals belong to the orthorhombic system, having space group Pbca with Z = 8 for the first and the third crystals (Orioli, *et al* 1966 and Fox *et al* 1964) and space group $P2_1\ 2_1\ 2_1$ with Z = 4 for the second (Cheeseman *et al* 1966). However, from the point of view of magnetic symmetry, in all these cases we can consider them as having only one magnetically inequivalent pair of ions in the unit cells. These complexes having a pair each of oxygens and nitrogens constituting the primary ligand cluster depart appreciably from a regular tetrahedron, the copper (II) complexes being flattened heavily along one of the S_4 axis while the Ni(II) complex may be assumed to have an orthorhombic symmetry. Incidentally this is the first report of single crystal anisotropy investigations in a tetrahedral chelate of Ni(II), the only compounds studied as yet are Ni^{2+} in host lattices of ZnO and CdO (Brumage and Lin 1964).